Renewable and Sustainable Energy Reviews 25 (2013) 260–271

Contents lists available at SciVerse ScienceDirect

Renewable and Sustainable Energy Reviews

journal homepage: www.elsevier.com/locate/rser

Overall review of renewable energy tariff policy in China: Evolution, implementation, problems and countermeasures

Zeng Ming, Liu Ximei*, Li Na, Xue Song

School of Economics and Management, North China Electric Power University, No. 2 Beinong Road, Huilongguan, Changping District, Beijing 102206, P.R. China

ARTICLE INFO

Article history:
Received 1 January 2013
Received in revised form
7 April 2013
Accepted 20 April 2013
Available online 25 May 2013

Keywords:
Renewable energy
Feed-in tariff
Renewable energy tariff policy
Tariff surcharge subsidies

ABSTRACT

The rapid growth of China's economy has accelerated its energy demand, which is becoming more urgent. It is essential to exploit renewable energy because of the limited conventional energy, high energy consumption and serious pollution. China will strengthen the development and utilization of wind, solar, biomass and other renewable energies in the future, which will reduce the level of carbon emissions. However, China's rapid growth in renewable energy, particularly wind, has been accompanied with some growing pains, and there is room for improving the legal framework to address these challenges. A reasonable renewable energy tariff policy has a pivotal role for changing China's current situation. This paper introduced the current development situation of renewable energy, analyzed the evolution and implementation effect of the renewable energy tariff policy and discussed the problems of the renewable energy tariff policy in China. On this basis, this article proposed feasibility tariff policy recommendations to solve the problems, which important theory significance and the practical application value.

Contents

* Corresponding author. Tel.: +86 18610756965; fax: +86 10 80793672.
E-mail addresses: meimeiliu126@163.com, meimeiliu126@sina.com (L. Ximei).

1364-0321
http://dx.doi.org/10.1016/j.rser.2013.04.026

1. Introduction

As one of the largest energy consumption countries in the world, China faces the challenge of accommodating the ever-growing energy demands, increased pollution, and rising greenhouse gas emissions [1]. Renewable energy development represents a fundamental part of the strategy for tackling this challenge. The Chinese government has ramped up efforts to achieve commercialization of the renewable energy sector, especially in the wind, solar and biomass industries. It is widely known that coal, oil, natural gas and other fossil energies have played a dominant role in primary energy consumption structure for a long time in China [2] (China's coal consumption was 3.425 billion t, accounting for 68.8% of the total primary energy consumption in 2011). The energy and environment problem becomes serious gradually with the development of the Chinese economy, which means that speeding up the development and utilization of renewable energy has become the most significant way to deal with these problems. China's renewable energy reserves are abundant, but the utilization rate is still low compared to the total reserves [3]. Against this background, the concept and objectives of developing renewable energy and achieving green growth have been incorporated in the “12th Five-Year Plan”, which focus on the development of wind power, hydropower, solar, biomass and other renewable energy sources [4]. Currently, due to the restriction of technical, cost and other factors, renewable energy generation development is still relatively slow in China. Therefore, various supporting policies are needed with the purpose of achieving the goal of developing renewable energy, such as tariff policy, fiscal policy and the quota policy, etc. [5]. The tariff policy, which plays an important role in promoting the development and utilization of renewable energy,

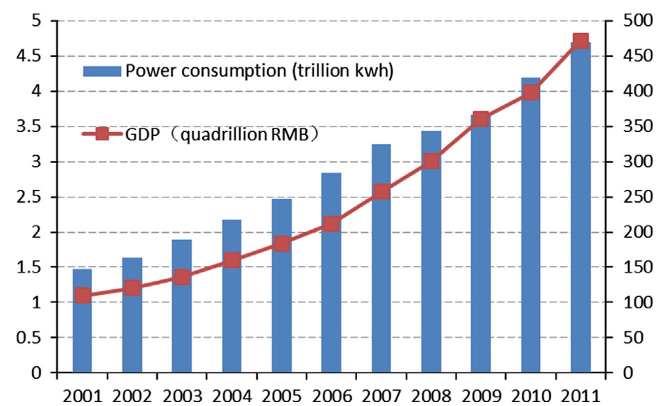


Fig. 1. China GDP and electricity consumption from 2001 to 2011 .
Statistics Source: China Statistical Yearbook, China Electric Power Yearbook.

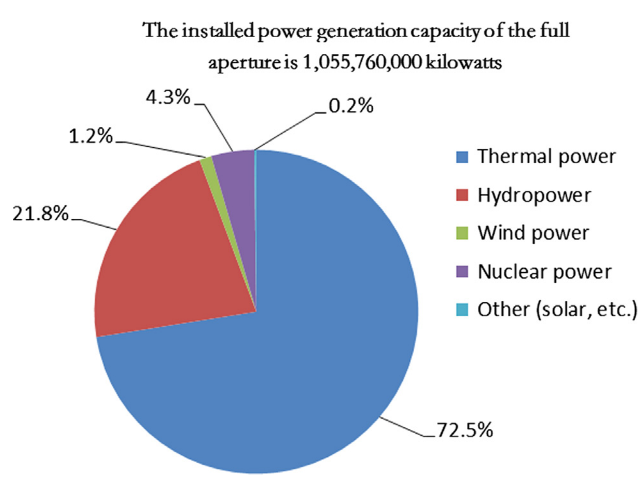


Fig. 2. Proportion of the energy structure of power generation capacity of full caliber in 2011 .
Source: Data from CEC (China Electricity Council).

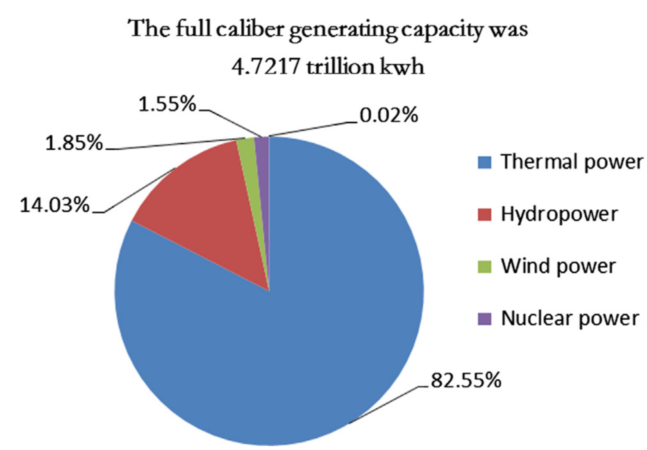


Fig. 3. Proportion of the energy structure of the generating capacity of China's full caliber in 2011 .
Source: Data from CEC (China Electricity Council).

Table 1
Key indicators for the development and use of renewable energy during the “12th Five-Year Plan”.
Source: “Renewable Energy in 12th Five-Year Plan”.

Content	Exploit scale quantity (million kW)	Annual output of energy (billion kW)	Standard coal (million t/yr)
Generation	394	1203	390
Hydropower (excluding pumped storage)	260	910	295.8
Wind power into the grid	100	190	61.8
Solar power	21	25	8.1
Biomass power	13	78	24.3
Agriculture and forestry biomass power generation	8	48	15.0
Biogas power generation	2	12	37.0
Garbage power generation	3	18	5.6

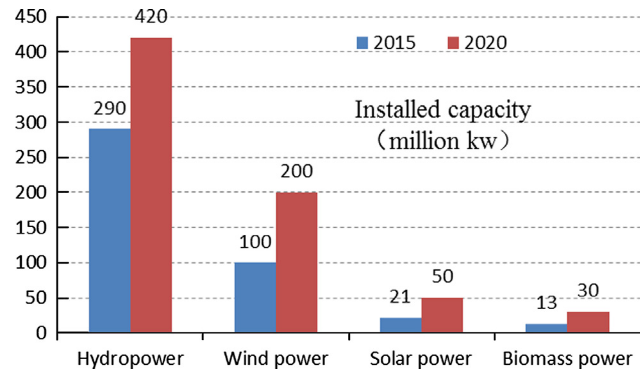


Fig. 4. Renewable energy planning objectives .
Source: "Renewable Energy in 12th Five-Year Plan" and "Biomass Energy in 12th Five-Year Plan".

Table 2
Wind resources in seven 10-million kW wind power bases.
Source: Institute of Geographical Sciences and Natural Resources, Chinese Sciences Academy.

Districts	Wind resources (250–300 W/m^2) (GW)	Wind resources (300 W/m^2) (GW)
Inner Mongolia	–	1300
Hami region in Xinjiang	–	250
Dam area in Hebei province	–	79.3
Jiuquan in Gansu province	–	210
Baicheng, Songyuan, Shuangliao in Jilin province	1100	15.4
Offshore of Jiangsu province (water depth of 5–25)	–	13.9
Inner Jiangsu province	3.4	–

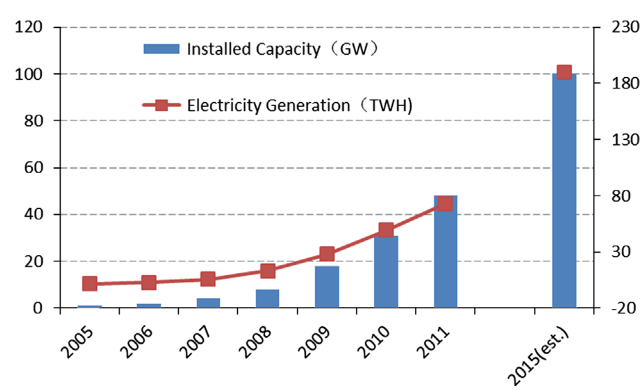


Fig. 5. On-grid wind power installed capacity and electricity generation from 2005 to 2011 .
Source: China Wind Energy Association (CWEA)

is one of the most direct, sensitive and effective means and has also been proved to be the most effective policy [6].

At present, China is in a key period of the electric system reform for the transformation of energy price mechanisms. The tariff policy, which promoted China's rapid growth in renewable energy, has been accompanied by some problems [7]. What effects do the promulgation and implementation of the tariff policy bring for industry development? How to improve the tariff policy with the development of renewable energy? How to maximize the role of the tariff policy to boost the healthy and sustainable development of renewable energy? This article will discuss these problems mentioned above deeply. The second part of this article will give an overview of China's renewable energy and the future development planning; the evolution, implementation and effects of the renewable energy tariff policy will be described in the third section; the fourth part will discuss the problems in renewable energy tariff policy, and then the feasibility recommendations for the problems will be put forward. The article will end with some conclusions about the development of China's renewable energy.

2. Renewable energy resources in China

2.1. Overview on renewable energy development

China's power industry has achieved rapid development, and china has become a major country in energy production and the demand for energy with the economic development continuously growing [8]. Electricity consumption of the whole society reached 4.6928 trillion kWh in 2011, a year-on-year increase of 11.74% as shown in Fig. 1.

China's total energy supply from renewable energy demonstrated an average annual growth rate of about 12% between 2000 and 2010 and substituted 293 million t of coal equivalents by the end of that period. Renewable energy has had rapid development, but is still a small proportion in the whole energy consumption. The issue of irrational power structure is increasing prominently. As Figs. 2 and 3 show, coal-fired electricity contributed around 80% of the electricity supply in China by 2011, and it also accounts for 72.5% of the installed power generation capacity of the accounting caliber and 82.55% of the generating capacity of the full caliber.

In order to adjust and optimize China's energy structure, "Renewable Energy in 12th Five-Year Plan" was issued by the National Energy Board, clearly pointed out that the renewable energy generation will rise to be an important power in the electricity system in the future and some specific development indicators will be put forward [9], as described in Table 1. Furthermore, the "Planning" also brings forward installed capacity target of hydropower, wind power, solar energy and biomass power, which is shown in Fig. 4. In the 12th Five-Year Plan, policy makers called for non-fossil fuel energy production to reach and stay above 11% of total energy production by 2015. If all renewable energy targets are met, the annual consumption of renewable

Table 3
Solar energy resource distribution in China.
Source: China Environmental Science Press, 2007.

Category	Annual solar radiation (kWh/m^2)	Percent of total area (%)	Areas
Most abundant	≥1750	17.4	Tibet, south Xinjiang, Qinghai, Gansu, and West Inner Mongolia
Very abundant	1400–1750	42.7	North Xinjiang, Northeast China, East Inner Mongolia, Huabei, North Jiangsu, Huangtu Plateau, East Qinghai and Gansu, West Sichuan, Hengduan Mountain, Fujian, South Guangdong, and Hainan
Abundant	1050–1400	36.3	Hill areas in Southeast, Hanshui river basin, West Guangxi
Normal	< 1050	3.6	Sichuan and Guizhou

energy will contributed to emission reduction of 1 billion t of carbon dioxide, 7 million t of sulfur dioxide, 3 million t of nitrogen oxides and 4 million t of dust, and a saving of 2.5 billion m^3 of water by 2015 [10].

2.2. Wind energy

China's wind energy resources can be developed about 1 billion kW, while the current exploitation is just 0.26 million kW, which means that the developing space is very considerable. China's wind energy resources are mainly concentrated in the north, northeast, northwest, southeast coastal areas and local inland areas [11], as shown in Table 2.

With the support of effective policy, the new installed capacity of wind power in China soared from 41.7 MW in 2001 to 17,630.9 MW in 2011. The cumulative installed capacity of wind power sharply increased from 381.2 MW to 62,364.2 MW. Fig. 5 is the installed capacity and electricity generation of on-grid Wind Power. China's wind power has achieved rapid development, but the gap between different regions is large [12]. For instance, the Inner Mongolia Autonomous Region's new installed capacity was 3736.4 MW in 2011, cumulative installed capacity reached 17,594.4 MW, while the cumulative installed capacity of Sichuan was only 16.0 MW.

The development goals of wind power in the future is pointed out in "Renewable Energy in 12th Five-Year Plan". The total on-grid wind power installed capacity will reach 100 GW and the annual electricity generation will be more than 190TWH, including 5 GW from offshore wind power installed capacity by 2015.The total on-grid wind installed capacity will reach 30 GW by 2020 [13].

2.3. Solar energy

China does have abundant solar energy resources, with more than 60% of its land area having abundant solar radiation, especially in the northwest, Tibet and Yunnan regions [13], as shown in Table 3. Although China is rich in solar resources, the provinces that receive the most sunlight are predominantly rural and not well connected to the national power grid [14]. The high prices of photovoltaic systems, small markets, and inconsistent grid connection standards have also been constraints on China's photovoltaic use [15].

In recent years, with the development of solar technology and materials industry, the cost of solar photovoltaic material continues to decline, which expands its installed capacity [16]. The installed capacity of solar power generation was approximately 3 GW in 2011, compared with 0.07 GW in 2005. As shown in Fig. 6.

The "Solar power development in the 12th Five-Year Plan" clearly defines the specific objectives of solar photovoltaic for the future. The solar power capacity will reach more than 21 million kW and the annual generation capacity will achieve 25 billion kW by 2015, including 10 million kW of total installed capacity of distributed photovoltaic power generation, 10 million kW of total installed capacity of grid-connected photovoltaic power generation capacity and 1 million kW of total installed capacity of solar thermal power.

2.4. Biomass energy

Biomass energy resources are abundant in China. According to resources, biomass energy can be divided into waste of agricultural, forestry, industrial, animal and sewage, and energy

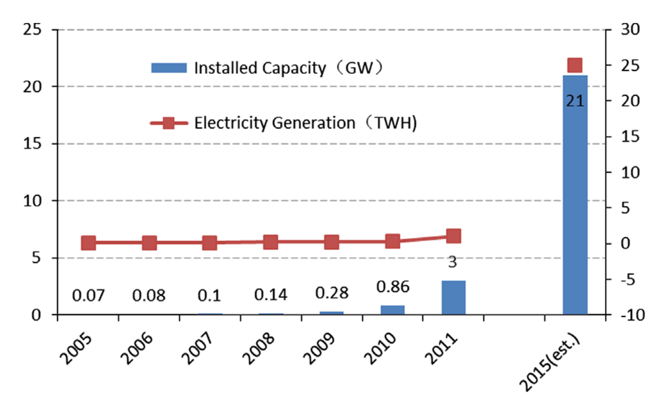


Fig. 6. Solar power installed capacity and electricity generation from 2005 to 2011 . *Source*: National Energy Board.

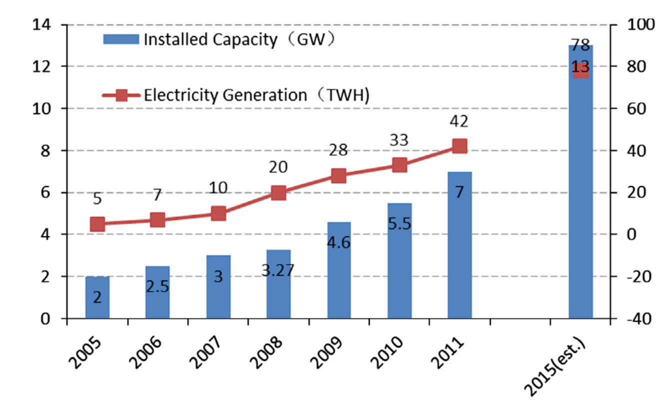


Fig. 7. Biomass installed capacity and electricity generation from 2005 to 2011 . *Source*: NDRC (Development and Reform Commission).

Table 4
China's biomass geographical distribution.
Source: NDRC (Development and Reform Commission).

Biomass species	Sequence	Range (t)	Provinces (regions)
Straw	The top five	> 4500	Henan, Shandong, Heilongjiang, Jilin, Sichuan
	After five	< 240	Tianjin, Qinghai, Tibet, Shanghai, Beijing
Forest	The top five	> 21,000	Tibet, Sichuan, Yunnan, Heilongjiang, Inner Mongolia
	After five	< 60	Jiangsu, Ningxia, Chongqing, Tianjin, Shanghai
Garbage	The top five	> 800	Guangdong, Shandong, Heilongjiang, Hubei, Jiangsu
	After five	< 181	Tianjin, Ningxia, Hainan, Qinghai, Tibet
Wastewater	The top five	> 250,000	Guangdong, Jiangsu, Zhejiang, Shandong, Henan
	After five	< 45,000	Gansu, Hainan, Ningxia, Qinghai, Tibet
Accumulator class	The top five	> 21,500	Henan, Shandong, Sichuan, Hebei, Hunan
	After five	< 3000	Hainan, Ningxia, Beijing, Tianjin, Shanghai

crops [17]. The distribution of biomass energy in China is uneven and the differences between provinces are obvious. About 70% of the biomass power generation, biomass liquid and gaseous fuels industry are distributed in 12 provinces and autonomous regions, as shown in Table 4.

With the support of national feed-in tariff incentives, China's biomass power industry had made significant progress [18]. Biomass power installed capacity reached 5.5 million kW in 2010, compared with 1.4 million kW in 2006, the average annual growth rate is 40.8%. The installed capacity and electricity generation of biomass is shown in Fig. 7.

"Renewable energy in the 12th Five-Year Plan" clearly pointed out that biomass power installed capacity will reach 13 million kW by the end of 2015, including 8 million kW of agriculture, forestry, biomass power generation, 200 million kW of biogas power generation and 300 million kW of garbage incineration power generation.

3. Renewable energy tariff policy evolution and effects

From the above analysis, it is obvious that China has great potential in renewable energy resources, and it also has made remarkable achievements in renewable energy's development and utilization. It is difficult to achieve rapid development for China's renewable energy without the supporting of tariff policy.

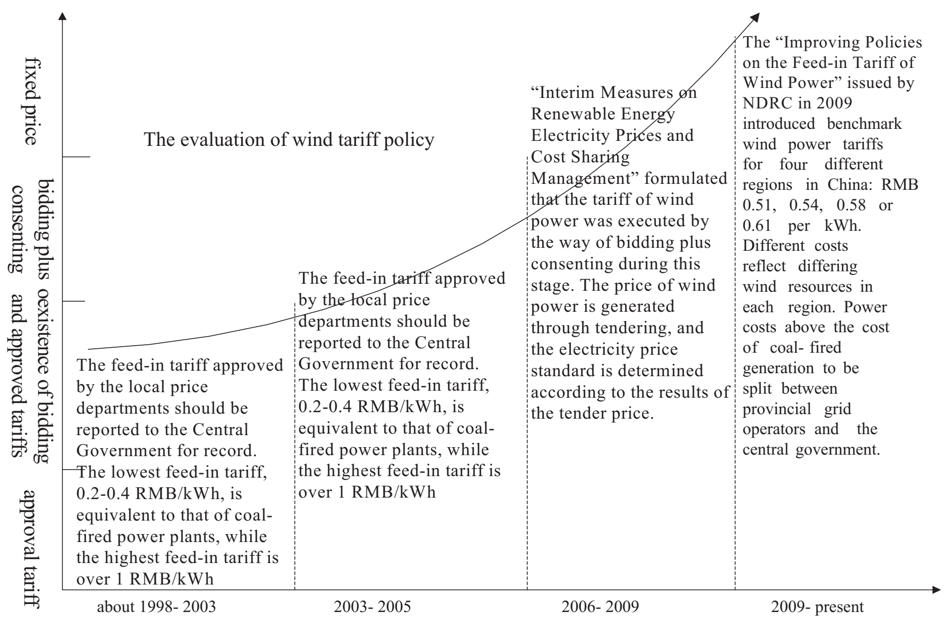


Fig. 8. Tariff policy evolution of wind power.

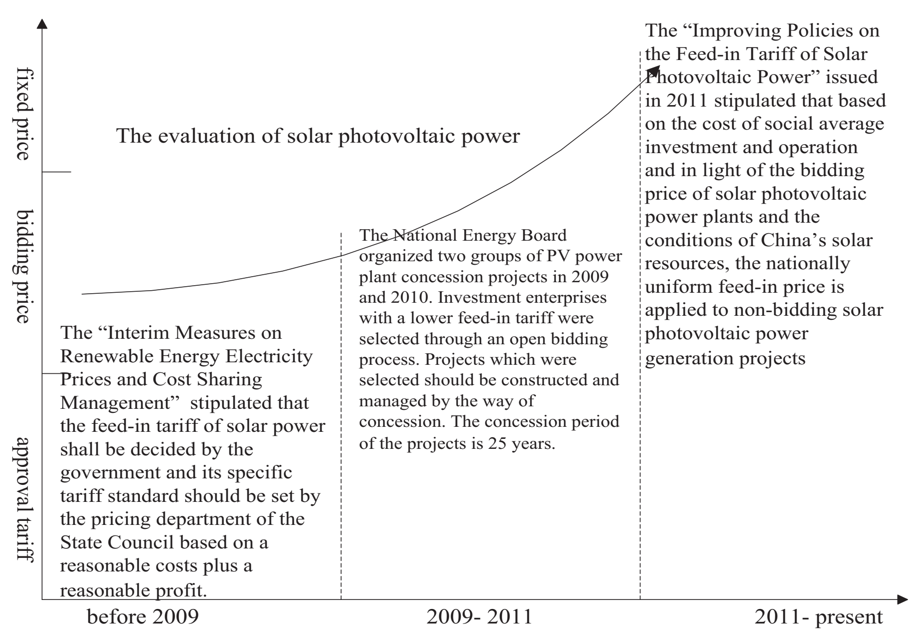


Fig. 9. Tariff policy evolution of solar photovoltaic power.

This section will focus on the tariff policy evolution of wind, solar and biomass energies, as well as the implementation effects.

3.1. Policy evolution and implementation

3.1.1. Feed-in tariff policy for renewable energy

Tariffs of wind power in China have experienced four stages: approval tariff stage, coexistence of bidding price and approved tariffs stage, bidding plus consenting stage and fixed tariffs stage, as shown in Fig. 8.

The specific implementation of wind power feed-in tariff is as follows: before 2003, the lowest feed-in tariff of wind power was 0.38 RMB/kWh, while the highest was more than 1 RMB/kWh [19]. After 2003, the NDRC organized a few of wind power concession projects, for which investors were selected via public tendering. However, the prices formed through concession bidding were generally low, about 0.38–0.5 RMB/kWh, while the prices without concession bidding approved by the local government were generally high, at 0.5–0.8 RMB/kWh. In July, 2008, the price level of 48 wind power projects approved by the NDRC was between 0.51 and 0.61 RMB/kWh [20]. The “Improving Policies on the Feed-in Tariff of Wind Power” promulgated by NDRC in August 2009, enacted a fixed feed-in tariff. The whole country is divided into four classes of wind energy resource regions with the benchmark feed-in tariffs were 0.51, 0.54, 0.58 and 0.61 RMB/kWh according to the policy [21].

Tariffs of solar photovoltaic power in China have gone through the approval tariff stage, bidding price stage and fixed price stage, as shown in Fig. 9.

The specific implementation of solar photovoltaic feed-in tariff is as follows: in 2007, the solar power price of Inner Mongolia, Shanghai and Chongming approved by NDRC was 4 RMB/kWh. In 2009, the feed-in tariff for the first batch of concession projects was 1.09 RMB/kWh, while the temporary feed-in tariff for solar photovoltaic power plant project in Ningxia was 1.15 RMB/kWh in April, 2010. In October, 2010, the lowest feed-in tariff for the second batch of concession projects was 0.73 RMB/kWh, while the highest was 0.99 RMB/kWh; in July, 2011, China's energy regulator announced a new circular on the feed-in tariff for solar photovoltaic power. The “Improving Policies on the Feed-in Tariff of Solar Photovoltaic Power” issued in 2011, introduced a unified feed-in tariff for solar photovoltaic power projects. The national feed-in tariff is RMB 1.15/kWh for projects completed by December 31, 2011, and RMB 1.0/kWh for projects approved by July, 2011, but not completed before the end of the year. The NDRC will from time to time adjust the price according to certain factors such as investment cost changes and technical advances [22].

Tariffs of biomass power in China have undergone governmental designated price and governmental guided price.

The specific implementation of biomass power feed-in tariff is as follows: before the establishment of a nationwide biomass feed-in tariff, under the policy set in 2007, the national feed-in tariff of biomass power exercised governmental designated price, which was equal to 0.25 RMB/kWh plus the 2005 benchmark desulfurized coal price in the area, where the facility was located for a period of 15 years [23]. On July, 2010, The “Improving Policies on the Feed-in Tariff of agriculture and forestry biomass power” issued in 2011 set at the feed-in tariff of the agriculture and forestry biomass power projects was 0.75 RMB/kWh [24].

3.1.2. Grid connection expenses

The “Interim Measures on Renewable Energy Surcharge electricity subsidy funds management” issued by NDRC stipulated that grid connection expenses paid by grid companies for the purchase of renewable power and other reasonable expenses may be

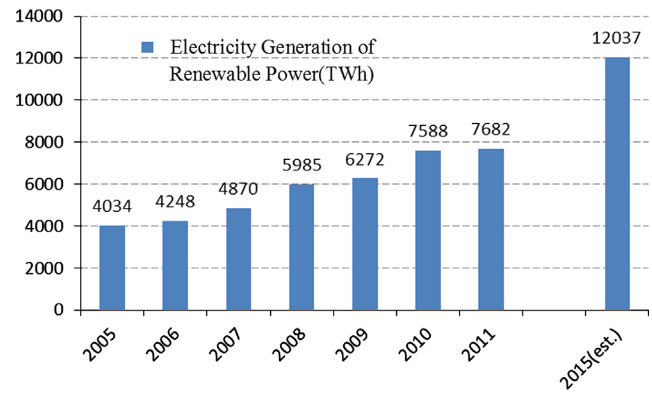


Fig. 10. Generation capacity of renewable energy from 2005 to 2011.

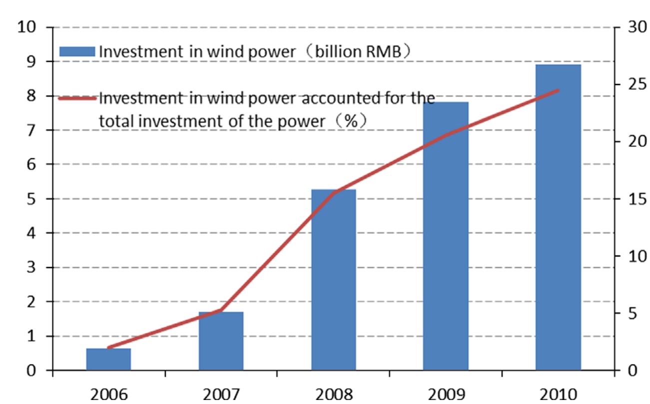


Fig. 11. Chinese wind power investment from 2006 to 2010.

Table 5
Specific implementations of tariff surcharge subsidies for renewable energy.

Tariff surcharge subsidies	Content
Scope	First, the part that renewable energy power feed-in tariff, approved by the government energy department, is higher than the local desulfurized coal benchmark price; second, the part that operation and maintenance costs of public renewable energy independent power system, constructed by government investment or subsidies, is higher than the average sale price of local provincial grid; and third, subsidies for the grid connection expenses of renewable energy power generation projects
Standard	The surcharge standard gradually increased from 0.001 RMB/kWh in June, 2006, not including electricity for agricultural use, to 0.002 RMB/kWh in July, 2008, except electricity for residential use and fertilizer, which remains 0.001 RMB/kWh, to 0.004 RMB/kWh in November, 2009 and up to 0.008 RMB/kWh in 2012
Collection	Renewable surcharge subsidies levied on electricity users (including the bulk sale object of the provincial grid company, captive power plant users, large users that buy electricity directly from the power plant) within the grid company services of provincial level and above. Users from urban and rural power supply grid, Tibet and engaged in agricultural production were temporarily waived

included into the power transmission cost of grid companies and retrieved from the selling price [25]. Depends on transmission distances and renewable power will be collected at 0.01 RMB/kWh for within 50 km, 0.02 RMB/kWh for 50–100 km, and 0.03 RMB/kWh for 100 km or longer distances [26].

3.1.3. Tariff surcharge subsidies

China's rapid deployment of renewable energy since the enactment of the Renewable Energy Law has been primarily funded through a national surcharge on electricity consumption [27]. The NDRC issued the “Interim Measures on Renewable Energy Electricity Prices and Cost Sharing Management” in 2006, which directed NDRC's pricing department to set a nationwide renewable energy surcharge levied on electricity users at a unified standard based on the users' consumption of electricity [28]. The policies, “Interim Measures on Revenue Allocation from Renewable Surcharges” “Interim Measures on the Renewable Energy Development Special Fund”, etc., defined the scope, standard and collection of the tariff surcharge subsidies for renewable energy. Specific implementations are as shown in Table 5.

3.2. Tariff policy effects

Chinese renewable energy has been gained rapid development since the Renewable Energy Law”, “Interim Measures on Renewable Energy Electricity Prices and Cost Sharing Management”, etc. were enacted. In recently years, China has made a significant progress in the exploitation and use of renewable resources. With continuous optimization of the energy structure, the proportion of the coal consumption drops from 95% in 1952 to 68.6% in 2010 and the proportion of the renewable energy increased step by step [29].

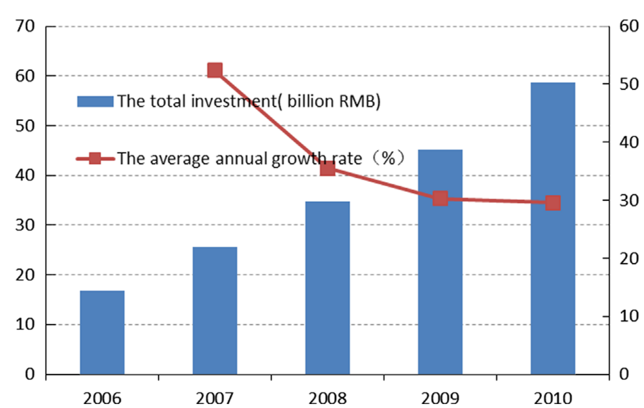


Fig. 12. Chinese biomass power investment from 2006 to 2010.

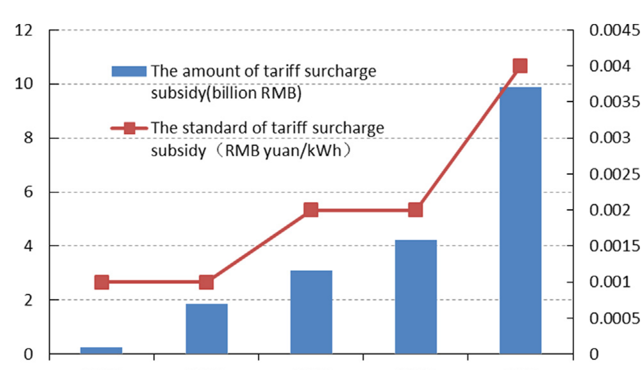


Fig. 13. Statistics of renewable energy tariff surcharge from 2006 to 2010.

3.2.1. Development of renewable energy industry

The enactment of the Renewable Energy Law and related tariff policies have been facilitated China's rapid deployment of renewable energy industry. The annual total use of renewable energy (including the use of solar thermal, gas and non-commercial renewable energy) was equivalent with about 300 million t of standard coal in China, accounted for 9.6% of the total energy consumption by the end of 2010 [30]. The production of installed capacity in the “11th Five-Year” period was 40 times more than that of the “10th Five-Year” period. In the global market, China's photovoltaic cell manufacturing industry annual output accounted for 40% of global production at the end of “11th Five-Year”; in domestic market, the new installed capacity in 2009 and 2010 was equivalent to the previous cumulative installed capacity [31]. Meanwhile, with the diversified development of biomass, the installed capacity of biomass power generation reached about 5.5 million kW by the end of 2010, the using amount of methane was about 13 billion m^3 and 1.8 million t of biological fuel alcohol. Fig. 10 shows the development of renewable energy generation capacity from 2005 to 2100.

3.2.2. Growth of renewable energy investment

The investment of renewable energy has been rapidly growing for the tariff policies were enacted. Firstly, the wind power investment. The investment of wind power construction in China increased rapidly compared with the previous period, with the average annual growth of 93.9% in the “11th Five-Year” period. China's investment of wind power was 81.9 billion RMB in 2010, a year-on-year increase rate of 13.9%. The proportion of wind power investment accounted for the total investment of power supply was increasing year by year, reached 24.27% in 2010 and increased by 22.5% compared to 2006 [32]. Chinese wind power investment from 2006 to 2010 is shown in Fig. 11. Secondly, the solar photovoltaic power generation investment. After 30 years' efforts,

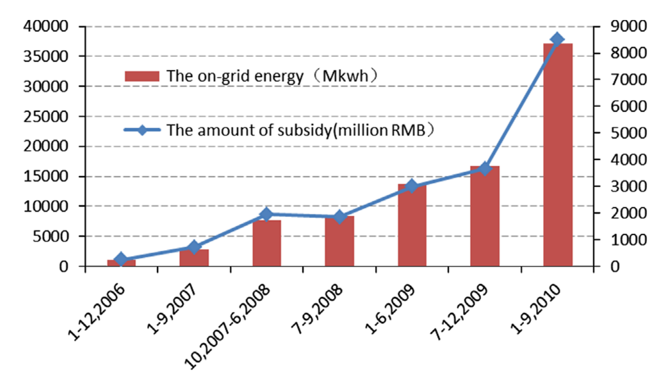


Fig. 14. Amount of subsidies for renewable energy power generation projects.

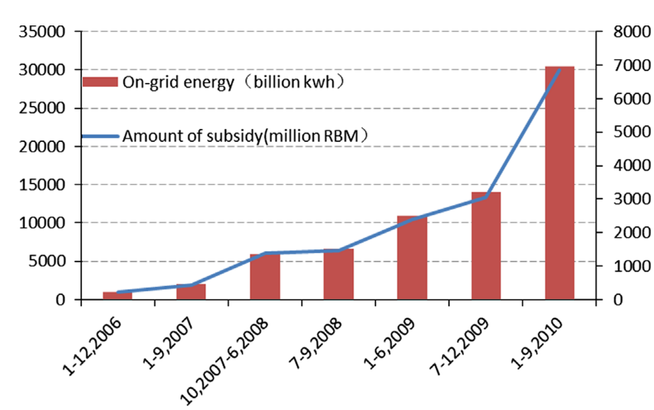


Fig. 15. Amount of subsidies for wind power generation projects.

Chinese photovoltaic power generation industry has ushered in a new stage of development. The investment in solar power has been experiencing a rapid growth. For example, the investment of the first CPV power plant project in Eerduosi, Neimenguwere started in 2006 and put into operation in 2008 was RMB 21 million; in 2009, the investment of 10 MW solar power plant project invested by Chinese government in Dunhuang, Gansu was 500 million; the 1 GW solar power plant project which divided into three stages in Caidamu Basin, Qihai was started in 2009, the size of first stage was 30 MW and the investment of first stage was RMB 1 billion [33]. China's investment in solar power generation is expected to reach 250 billion RMB during the 12th Five-Year Plan. Thirdly, the biomass power generation investment. By the end of 2009, the total investment of the biomass power generation in China was 45.2 billion RMB, compared with 2006 of 16.8 billion RMB, which increased 39.1% averagely during that time. The total installed capacity that has been put into operation, was 1.4 million kW in 2006 increased to 4.3 million kW in 2009, with an average annual growth rate of 45.4%. The installed capacity of biomass power was more than 5 million kW and the cumulative investment has been reached to 58.6 billion RMB in 2010 [34], as shown in Fig. 12.

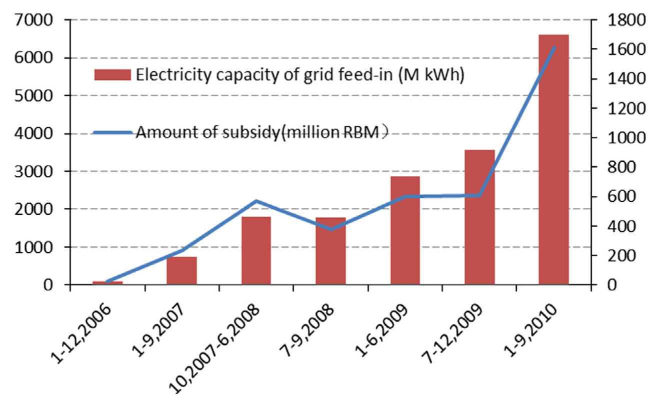


Fig. 16. Amount of subsidies for biomass power generation projects.

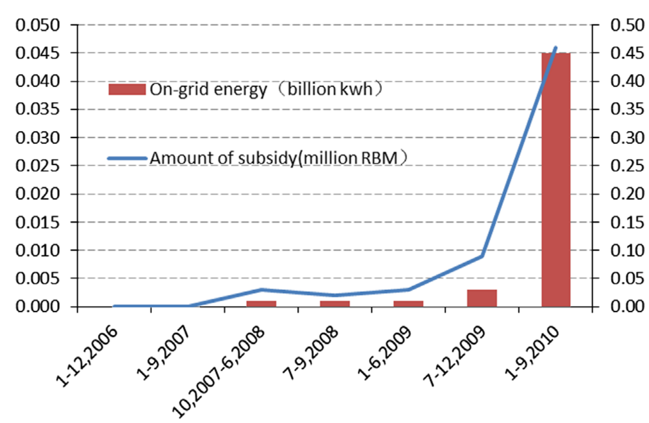


Fig. 17. Amount of subsidies for solar photovoltaic power generation projects.

3.2.3. *Increase of renewable energy subsidies*

Since the Renewable Energy Law was enacted, China has made a significant increase in renewable energy subsidies. The original Renewable Energy Law expressly stated that the costs associated with feed-in tariffs and the reasonable costs associated with connecting renewable generators to the grid are to be shared nationwide through a surcharge on end-users of electricity. From 2006 to 2008, 483 renewable energy projects obtained 5.25 billion RMB subsidies through tariff surcharge compared to 6.652 billion RMB in 2009; 65 public renewable energy independent power systems obtained subsidies 25 million RMB compared to 60 million RMB in 2009; 173 access network projects of renewable energy generation obtained 73 million RMB subsidies compared to 269 million RMB in 2009. The total amount of subsidies has grown rapidly, from 5.35 billion RMB in 2006–2008 to 6.98 billion RMB in 2009 [35]. Fig. 13 shows the statistics of renewable energy tariff surcharge subsidy from 2006 to 2010.

The amount of China's renewable energy tariff surcharge subsidy was 8.91 billion RMB from January 2010 to September. The amount of subsidies for renewable energy generation projects, wind power projects, biomass power generation projects and solar photovoltaic power generation projects is shown in Figs. 14–17.

Table 6
The amount of subsidies for public renewable energy independent power systems, 1–9, 2010.

Area	Project name	Installed capacity (kW)	Subsidies (million RMB)
Gansu	Off-grid wind–solar-electricity "Send Electricity to the Village" project	971.00	1.9420
	Sino–Japanese cooperation in Dunhuang Jadin project	200.00	0.6000
	Sino–German cooperation projects for financial assistance	123.70	0.3711
Qinghai	The "Send Electricity to the Village" project of Qinghai Province	3943.00	11.8290
	Sanjiangyuan project	519.38	1.5581
	Qinghai subprojects of Sino–German cooperation projects on solar photovoltaic power plant	454.40	1.3632
Xinjiang	1 and 2 phases of wind energy company Sino–German project	100.50	0.3015
		289.60	0.8688
	The solar photovoltaic power station of Xinjiang Production and Construction Corps	1310.00	39.300
	The "Send Electricity to the Village" project of Xinjiang Province	1561.30	46.8.39
Tibet	The independent system of Tibet Autonomous Region	3000.00	9.0000
Yunnan	Sino–German financial cooperation on Yunnan solar project	100.50	0.3015
	Sino–German technical cooperation (Yunnan) on solar power supply system project	298.50	0.8955
	Sino–German financial cooperation on Yunnan solar projects (new production parts)	233.60	0.7008
	Sino–German technical cooperation on solar power supply system project (new production parts)	12.80	0.0384
Sichuan	The "Send Electricity to the Village" project of Ganzi, Aba, etc.	1245.55	3.7367
Mengxi	The "Send Electricity to the Village" project of Inner Mongolia	662.45	1.9873
Total		15,026.28	44.1078

From January 2010 to September, the total installed capacity of public renewable energy reached 15,000 kW, 16 independent power systems of public renewable energy obtained subsidies for 44 million RMB, as shown in Table 6.

From January 2010 to September, 407 access network projects of renewable energy power generation obtained 366 million RMB cumulative subsidies. Fig. 18 is the amount of subsidies for access network projects of renewable energy.

4. Problems and countermeasures of renewable energy tariff policy

4.1. Problems of renewable energy tariff policy

The evolution and implementation of renewable energy tariff policy have been discussed in this article. It can be seen from the above analysis that the tariff policy has promoted the development of renewable energy at the beginning of implementing, however, at the same time, some factors of tariff policy that hinder its development are gradually turned up with the rapidly changing of external environment and rapidly development of renewable energy. In general, the imperfections of current tariff policy probably make the development of China's renewable energy industry in a relatively passive situation. And specifically, the problems mainly exist in the specific implementation of tariff policy, such as the problems of feed-in tariff, grid connection expenses and tariff surcharge subsidies. Which all probably will become the restrictive factors for the development of renewable energy.

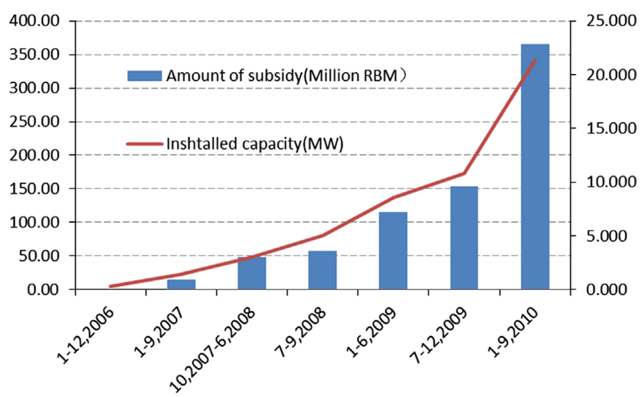


Fig. 18. Amount of subsidies for access network projects of renewable energy from 2006 to 2010.

4.1.1. Problems of feed-in tariff

The current renewable energy feed-in tariff policies still have many shortcomings which need to be improved urgently. The problems are mainly reflected in the following aspects: for wind power, the fixed benchmark price cannot play the role of price signal to guide investment, which ensures that wind farms can achieve certain return on investment. However, it also isolates the wind farm from market signals-price. Wind farms cannot respond to market price signals, which make the peak-to-valley difference increased and the anti-peaking effect is obvious [36]. Second, because the feed-in tariff is bidding and approved in accordance with every single project, there is no definite signal for investor to exploit wind resource, which results in the investments for wind power from foreign and private companies will be inevitably affected. With the trial implementation of the policy, the investors of wind power projects are mainly large state-owned power generation and energy companies, regardless of tendering by the central government organizations or approving by the local authorities, which are likely to cause industry monopoly and not conducive to the formation of wind power competitive market. Third, the pricing way of the wind power feed-in tariff is not fair. For example, wind farms at the junction of two different tariff levels owned similar wind resources may be significant differences in the feed-in tariff. This unfair phenomenon led to two negative results that the tariff signal is not clear and cannot play the role of guiding wind power investment.

For solar photovoltaic power generation, the problems of public tender price policy include: First, the lack of the necessarily supporting policies for solar power tendering tariff system which results in the bidding price is a serious deviation from the actual cost. Blind price competition exists in bidding process caused intense price war. This negative impact extends to the upstream industry chain from downstream operators, and seriously

Table 7
Provinces (autonomous regions/municipalities) renewable energy tariff subsidies statistical.
Data Source: State Electricity Regulatory Commission.

Province	Renewable energy tariff additional income balance (after tax)	Renewable energy projects should be subsidies amount (excluding tax)	Province	Renewable energy tariff additional income balance (after tax)	Renewable energy projects should be subsidies amount (excluding tax)
Beijing	13,329.51	2584.11	Jiangsu	24,869.40	78,712.20
Tianjin	15,494.00	918.0	Zhejiang	16,745.39	6145.78
Hebei	27,652.40	47,543.96	Anhui	9756.40	7622.98
Shanxi	14,657.64	7785.77	Fujian	15,463.62	18,337.65
Shandong	30,027.30	34,717.36	Hubei	14,497.84	4994.14
Inner Mongolia (western)	19,055.52	32,973.73	Henan	21,709.05	15,031.00
Inner Mongolia (eastern)	3079.90	18,425.54	Hunan	16,969.51	1804.39
Liaoning	21,487.00	29,897.00	Jiangxi	13,333.59	2244.33
Jilin	8834.76	19,445.34	Sichuan	25,456.45	1634.56
Heilongjiang	8737.79	51,028.88	Chongqing	10,756.00	1256.00
Shaanxi	10,286.0	810.00	Guangdong	99,998.92	532.11
Gansu	12,403.89	6616.02	Guangxi	16,016.71	1836.55
Ningxia	6445.14	15,797.41	Yunnan	16,616.30	3631.75
Qinghai	1065.9888	1326.93	Guizhou	19,848.58	–
Xinjiang	5260.37	40,298.21	Hainan	3051.02	580.5
Shanghai	23,788.3	1625.98			

damages the sustainable development of the solar power industry. Second, the expected return on investment caused by the price war is low, and private investors are reluctant to get involved in solar power operators, which lead to the investors mainly are large and medium-sized state-owned energy groups. Therefore, the investment demand of wind power is suppressed to an extent [37]. The problems of non-tender projects with unified feed-in tariff policy include: unified feed-in tariff is contrary to the distribution of resource in China. China's solar resource is divided into four regions based on the richness of the solar resource, using a unified benchmark price will against to the development of solar power. Solar power investors, with a unified benchmark price, will increase the installed capacity of solar photovoltaic power in western regions where sunshine resources are abundant. However, the grid support technology in western region is poor, and the grid connection problem is also not resolved, which may result in the waste of investment and will reversely have impact on a balanced development of the Chinese solar photovoltaic power industry. Second, with the limitations of solar resources, the investment recovery period of solar power generation projects in eastern China is longer compared with western China, which hinders the development of photovoltaic power generation in that region. As a result, the development of relevant industries in the east and west will face imbalance predicament.

For biomass power, first, biomass power industry is still in its infancy in China, with the lower level of technology and higher costs, biomass power feed-in tariff is relatively high, which makes the biomass power generation companies unable to compete with conventional energy companies in the electricity market [38]. Under the circumstances, the development of biomass energy industry will suffer adverse effects from the high feed-in tariff. Second, there could be adverse consequences for using various biomass resources effectively with a unified feed-in tariff. Based on the current renewable energy tariff management approach, the price of biomass power generation uses the same standard in the same area, but this is obviously contrary to the status quo of China's economic development and resources distribution. Currently, the economic development level in eastern China is much faster than that in western region. The imbalance of economic development among different provinces causes that the difference among technical level, financial strength and the labor costs is huge, which results in the biomass power generation cost of the various provinces is also different. As is known to all, formulating a unified tariff for the different costs of power generation is contrary to the principles of economics. Third, the pricing policy of co-firing biomass power generation projects is not clearly enough. The co-firing power price policy has not been introduced, because monitoring is difficult, and the necessary technical means for monitoring are also scarce, which will not be conducive to the diversity development of biomass energy.

4.1.2. Problems of grid connection expenses

For the grid connection expenses, the main problems include: first, the subsidy standard of grid connection engineering is low. The current subsidy standard of grid connection expenses is between 0.01 and 0.03 RMB/kWh, which is unable to meet the needs of the grid connection engineering investment and unattractive to companies for investing in power [39]. In 2008, the subsidies for grid connection expenses gained in accordance with the regulations was more than 280 million RMB in Ningxia, more than 320 million RMB in Gansu, more than 330 million RMB in Xinjiang, which were only enough to cover the debt service costs of the power transmission and transformation investment of existing transmission projects [40]. The expenditure of the transmission projects is woefully inadequate, which negatively affects the normal production and operation of the power grid companies. Second, the subsidy policy does not reflect the actual project investment costs of grid connection engineering. Existing subsidy policy of grid connection does not consider the factors of electrical energy long-distance transmission and the grid expansion sending and receiving side of large-scale renewable energy generation base. The subsidy policy for grid connection formed on above basis is unreasonable, which is against to investment and development of renewable energy.

4.1.3. Problems of tariff surcharge subsidies

The main problems of tariff surcharge subsidies include: On the one hand, the levied standard of renewable energy tariff surcharge subsidies is low, which is unable to meet the needs of future development of renewable energy. According to the “Medium and long-term development plan for renewable energy” issued by NDRC in 2007, the proportion of renewable energy in energy structure will reach 15% in 2020. However, the rise in tariff subsidies standard is limited. The growth rate of renewable energy production will be much higher than that of taxable electricity of tariff surcharge, which means that the subsidy gap will be widening. There was a shortage of about 2 billion RMB for renewable energy subsidies in 2010, which increased sharply in 2011, up to 10 billion RMB, as shown in Table 7. On the other hand, time-lag effect exists in the allocation of subsidy fund in the actual operation. According to the “Interim Measures on Revenue Allocation from Renewable Surcharges”, the equalization of surcharges and payments of subsidies to renewable generators were required to occur monthly. However, the equalization has occurred every six–nine months in practice [41]. This delay is the result of the complicated, bureaucratic process of determining how much each province is entitled to and the funds should be collected from which other provinces. As a result of time-lag effect, a renewable generator entitled to a feed-in tariff will not receive the appropriate subsidy above the cost of coal-fired power until at least six months after the energy was actually sold to the grid company. This delay in collecting subsidies has put a strain on the cash flow for renewable power generators and their investors, ultimately hinder the scaling-up of investment needed for China to reach its renewable energy development goals [42].

4.2. Countermeasures of renewable energy tariff policy

In a market economy, price is the most effective adjustment mechanism. Reasonable price policy play a pivotal role in going out of the predicament of renewable energy's development and achieving the target of the “12th Five-Year Plan”. Consequently, the corresponding countermeasures and suggestions about feed-in tariff, grid connection expenses and tariff surcharge subsidies were proposed in the following sections in view of the problems existed in tariff policy of renewable energy.

4.2.1. Perfect feed-in tariff policy for renewable energy

For wind power, first, improving wind power price mechanism is urgently. It is recommended that the part of wind power feed-in tariff paid by the grid companies should be fixed. The main factor that affects the desulfurization benchmark electricity price is the fluctuation of coal prices. In accordance with existing regulations, grid companies firstly pay part of the local desulfurization benchmark price, the rest part should be paid by renewable energy subsidy incomes [43]. However, there are no direct and contrastive relations among wind power feed-in tariff, coal price and coal-fired power feed-in tariff. It is unreasonable for grid companies to pay wind power price based on the rising of desulfurization benchmark feed-in tariff. Therefore, it is a feasible choice that

the payment standard level of grid companies can be fixed by using a desulfurization benchmark price with particular year. Second, this article proposed that the four wind power benchmark price regions should be reduced to two. One price is for rich wind energy resources region, which combined the current class I and II into a large class with benchmark price of about 0.60 RMB/kWh. Another price is the rest region of the country, which merged the current class III and IV into a large class with benchmark price of about 0.65 RMB/kWh. Third, the preferential wind power feed-in tariff policy should take full account of the assimilative capacity of grid. The tariff policy should always play the role of market signals, which is beneficial to ensure wind power investors make reasonable investment. As a result, the grid companies can maintain a reasonable proportion of wind power capacity in the total capacity, which can prevent the generation capacity from exceeding the actual affordability of the grid.

For solar photovoltaic power, policy-makers need to refine the attractive pricing policies and adjust the price at any time based on the changes of the cost of power generation. The demonstration projects should be put out to tender actively on the basis of establishing reasonable price standards, and the price standards should ensure investors of solar power projects are able to get a reasonable rate of return on investment, which can provide some growth space for the development of solar photovoltaic industry.

For biomass power generation, in view of the externality of electricity products and the raw material costs of biomass power generation, the prices for different types of biomass should be determined according to the principles of encouraging the production of biomass power generation when the market of biomass power generation industry formed to a certain level.

4.2.2. *Perfect grid connection expenses*

For renewable energy grid connection expenses, it is necessary to alter the way of current grid connection subsidy into financial incentives which can change the status quo for the lower grid connection expenses of renewable energy generation. The future policy for raising the subsidy standard should be developed to guarantee that the grid connection project investments can be recouped [44]. For small-scale wind power base, this subsidy standard can be determined by benchmarking way and collected according to on-grid energy. For large-scale wind power base, it is sensible that the price subsidies standard of grid matching engineering be individually approved due to the factors of electricity and energy long-distance transport and grid expansions of sending and receiving side of renewable energy power generation base [45]. In addition, in order to promote the renewable energy development, it is necessary for future tariff policy makers to refine that the a higher part of the grid matching engineering costs of renewable energy generation base than construction and operation costs of conventional generation base which will be shared in the country through renewable energy tariff surcharge.

4.2.3. *Perfect subsidy standard for renewable energy*

Although the subsidy standard for renewable energy has increased, energy experts said that there is still room for lifting. China's annual renewable energy installed capacity increased by more than 30%, while the national electricity consumption growth rate remained at about 10%. This growing gap between installed capacity and electricity consumption will result in the expansion of renewable energy subsidy funding gap, which can be solved by increasing the standard of renewable energy subsidy. According to the development planning of renewable energy, it is recommended that the subsidy standard should be lifted to 0.01 RMB/kWh in 2020 in order to better promote the development of renewable energy industry. Under the standard of 0.01 RMB/kWh, the cumulative subsidies for renewable energy power generation will reach 643 billion RMB by 2020.

5. Conclusion

Renewable energy is the inevitable choice for sustainable economic growth. In order to promote and ensure the rapid, effective and sustainable development of renewable energy, the Chinese government has formulated a series of tariff policies on renewable energy development. These policies play a significant pushing and guiding role in the development and use of renewable energy. This review paper details and presents the status of China's renewable energy tariff policy, including the policy evolution, implementation, effects, problems and countermeasures, Which has a very important role in the development of renewable energy.

As mentioned in the introduction of this article, the tariff policy is just one of the important measures to promote the development of renewable energy, it is necessary to consider other supporting policies and market-oriented reforms for the sustainable development of renewable energy. Therefore, the scholars can conduct their studies from the following aspects in the future: (1) the reform of renewable energy's management system. It is necessary for scholars to research how to form a perfect co-management mechanism that government, market and public are all involved in. a good market is a prerequisite for the large-scale development and commercialization of renewable energy; and eliminating market barriers is the key to sustainable development of renewable energy; it is needed to strengthen the legalistic and political constraints and accountability responsibilities to the Government and other relevant authorities' behaviors when they fulfill their energy management duties if the industry want to get an important guarantee for its development. Strengthening participation of the public is another important complement to the development of renewable energy. Therefore, shifting the research focus from the traditional state-directed energy development model to the new model that involves in cooperation and division of government, market and society's work is very urgent and critical. (2) The technology innovation about renewable energy. Presently, some achievements have been made in China's renewable energy industry and the relevant technology development. However, the development and utilization technology of China's renewable energy is still in its infancy compared with developed countries, which means that its technology development and innovation capacity is still weak and it still does not form a perfect technical service system. Therefore, the future studies can focus on how to improve efficiency, reduce costs and solve other problems encountered in the process of renewable energy development and utilization through technological means. (3) The renewable Portfolio Standard (RPS). RPS as an effective mechanism for promoting the development of renewable energy has been implemented successfully in Europe and the United States. the current policies cannot solve all the problems of generation and connection on the grid of renewable energy and market disposing with unbalance resource distribution and irrational energy structure in China. Therefore, introducing RPS policy has importantly practical significance. What obstacles and risks will emerge for the development of renewable energy if RPS was introduced in China and how to design a reasonable policy framework in accordance with China's specific circumstances, all of these need further study.

From the future perspective, a vast development space can be provided to renewable energy. With the development of technology and the improvement of supporting policy, the renewable energy will be on a stage of rapid development in the next period of time. The development of renewable energy is a major strategic

move for regulating the total energy consumption and constructing a safe, modern, stable and economic, clean energy industry system. Therefore, in the light of the deployments of developing strategic emerging industries, the related institutional innovation and market-oriented reforms should be introduced in order to create a good environment for large-scale exploitation and utilization of renewable energy and industrial development, which can promote a omni-directional, diversified and large-scale development for renewable energy and help China achieve emission reduction targets.

Acknowledgments

The authors wish to acknowledge Xue Song and Li Na for providing much valuable information and statistics on renewable energy and Wang Liang for improving the quality of the writing. This paper are supported by the National Natural Science Foundation of China (Grant no. 71271082) and the National Soft Science Research Plan (Grant no. 2012GXS4B064) of China.

References

[1] HuiLiao Ching, Ou Hsin Hung, Lo Shang Lien, Chiueh Pei Te, Yu Yue Hwa. A challenging approach for renewable energy market development. Renewable and Sustainable Energy Reviews 2011;15:787–93.
[2] Liuyijun. Analysis of China's current energy structure and trend of development: supply and demand. Energy Procedia 2011;5:2593–8.
[3] Lin Boqiang, Jiang Zhujun. Estimates of energy subsidies in China and impact of energy subsidy reform. Energy Economics 2011;33:273–83.
[4] Na Zhang, Noam Lior, Hongguang Jin. The energy situation and its sustainable development strategy in China. Energy 2011;36:3639–49.
[5] Min H, Yong H, Haiyan C. Predictive analysis on electric-power supply and demand in China. Renewable Energy 2007;32:1165–74.
[6] National Bureau of Statistics of China. Annual Report on the National Economy and Social Development of P.R. China 2009. Beijing: China Statistics Press; 2010.
[7] Jiang B, Sun ZQ, Liu MQ. China's energy development strategy under the low carbon economy. Energy 2010;35:4257–64.
[8] Zhemin Jiang. Considerations to the energy problems in China. Energy in China 2008;30:5–19.
[9] Ma HY, Oxley L, Gibson J. China's energy situation in the new millennium. Renewable and Sustainable Energy Reviews 2009;13:1781–99.
[10] Shen YC, Lin G, Li TR, Yuan KP, Benjamin JC. An assessment of exploiting renewable energy sources with concerns of policy and technology. Energy Policy 2010;38:4604–16.
[11] Research report on the wind power development in China. The State Electricity Regulatory Commission. Beijing, China 2009.
[12] Li YF, Yue XH. Analysis on China's biomass power generation industry: the current situation, problem and its legislation and policy recommendations. Journal of China University of Geosciences (Social Sciences Edition) 2009;9:37–41.
[13] National Development and Reform Commission. Outline of the People Republic of China's Twelfth Five Year Plan for Economic and Social Development. Available from: ⟨www.ndrc.gov.cn/fzgh/ghwb/gjjh/P020110919592208575015.pdf⟩; 2011a.
[14] Liu T, Xu G, Cai P, Tian L, Huang Q. Development forecast of renewable energy power generation in China and its influence on the GHG control strategy of the country. Renewable Energy 2011;36:1284–92.
[15] Solangi KH, Islam MR, Saidur R, Rahim NA, Fayaz. H. A review on global solar energy policy. Renewable and Sustainable Energy Reviews 2011;15:2149–63.
[16] Zhao R, Shi G, Chen H, Ren A, Finlow D. Present status and prospects of photovoltaic market in China. Energy Policy 2011;39:2204–7.
[17] Zhang N, Lior N, Jin H. The energy situation and its sustainable development strategy in China. Energy 2011;36:3639–49.
[18] Zhao Xingang, Wang Jieyu, Liu Xiaomeng, Liu Pingkuo. China's wind, biomass and solar power generation: what the situation tells us? Renewable and Sustainable Energy Reviews 2012;16:6173–82.
[19] Ru P, Zhi W, Zhang F, Zhong XT, Li JQ, Su J. Behind the development of technology: the transition of innovation modes in China's wind turbine manufacturing industry. Energy Policy 2012;43:58–69.
[20] Yan Qingyue, Li Zhen. An analysis of biomass power generation cost-sharing mechanism in China. Economic Management 2011;2:1–6.
[21] Lewis JI. Building a national wind turbine industry: experiences from China, India and South Korea. International Journal of Technology and Globalisation 2011;5:281–305.
[22] National Development and Reform Commission. Notice on perfecting wind power feed-in pricing policies. NDRC Pricing Bureau. No.1906,2009. Available from:⟨www.ndrc.gov.cn/zcfb/zcfbtz/2009tz/t20090727_292827.htm⟩; 2009.
[23] National Development and Reform Commission. Notice on perfecting solar P.V. power feed-in pricing policies. NDRC Pricing Bureau. No.1594, 2011. Available from: ⟨www.ndrc.gov.cn/zcfb/zcfbtz/2011tz/t20110801_426501.htm⟩; 2011b.
[24] Ministry of Finance, Finance and Construction Department. Interim Measures on the Straw Biomass Utilization Subsidies Fund No.735, 2008. Available from: ⟨jx.mof.gov.cn/lanmudaohang/zhengcefagui/200904/t20090413_131995.html⟩; 2008.
[25] National Development and Reform Commission. Notice on perfecting agricultural and forest biomass power electricity price policies. NDRC Pricing Bureau. No.1579, 2010. Available from:⟨www.ndrc.gov.cn/zcfb/zcfbtz/2010tz/t20100728_363362.htm⟩; 2010.
[26] Ministry of Finance, National Development and Reform Commission, and National Energy Agency. Interim Measures on management of the renewable energy electricity price additional subsidy funds. Ministry of Finance, Finance and Construction Department. No.102[2012]. Available from: ⟨http:/www.gov.cn/zwgk/2012-04/05/content_2107050.htm⟩; 2012.
[27] Zhao Xingang, Liu Xiaomeng, Liu Pingkuo, Feng Tiantian. The mechanism and policy on the electricity price of renewable energy in China. Renewable and Sustainable Energy Reviews 2011;15:4302–9.
[28] Research report on study on pricing and cost sharing mechanism for renewable electricity. Energy Research Institute of National Development and Reform Commission. Beijing, China; 2010.
[29] Schuman S, Lin A. China's Renewable Energy Law and its impact on renewable power in China: progress, challenges and recommendations for improving implementation. Energy Policy 2012. http://dx.doi.org/10.1016/j.enpol.2012.06.066.
[30] Interim measures on renewable energy electricity prices and cost sharing management. NDRC Pricing Bureau, No.7,2006. Available from: ⟨www.gov.cn/ztzl/2006-01/20/content_165910.htm⟩.
[31] Zhen YuZhao, Jian Zuo, Lei Leifan, George Zillante. Impacts of renewable energy regulations on the structure of power generation in China: a critical analysis. Renewable Energy 2011;36:24–30.
[32] Huang Junyi. The policy comparison on renewable energy price regulation. Journal of Taiyuan University of Technology (Social Sciences Edition) 2011;6:29–33.
[33] Renewable energy in China: a necessity, not an alternative. ⟨http:/knowledge.wharton.upenn.edu/article.cfm?articleid=2214⟩; 2009.
[34] Wang Z, et al. China's wind power industry: policy support, technological achievements, and emerging challenges. Energy Policy 2012. http://dx.doi.org/10.1016/j.enpol.2012.06.067.
[35] Huo M-l, Zhang D-w. Lessons from photovoltaic policies in China for future development. Energy Policy 2012.
[36] Zhang Peidong, Yang Yanli, Tian Yongsheng, Yang Xutong, Yongkai Zhang, Zheng Yonghong, et al. Bioenergy industries development in China: dilemma and solution. Renewable and Sustainable Energy Reviews 2009;13:2571–9.
[37] Xue Liangyuan, Jian Zuo. Pricing and affordability of renewable energy in China: a case study of Shandong Province. Renewable Energy 2011;36:1111–7.
[38] He YX, Zhu MZ, Xiong W, Zhang T, Ge XL. Electricity transmission tariffs for large-scale wind power consumption in western Gansu province, China. Renewable and Sustainable Energy Reviews 2012;16:4543–50.
[39] Zhang Sufang, Li Xingmei. Large scale wind power integration in China: analysis from a policy perspective. Renewable and Sustainable Energy Reviews 2012;16:1110–5.
[40] Peidong Z, Yanli Y, Jin S, Yonghong Z, Lisheng W, Xinrong L. Opportunities and challenges for renewable energy policy in China. Renewable Sustain Energy Review 2009;2:439–49.
[41] Hao Shanshan, Zhang Dongxia, Pricing Policy and Risk Management Strategy for Wind Power Considering Wind Integration. Power System Technology 2011;5:142–5.
[42] Jiang B, Sun ZQ, Liu MQ. China's energy development strategy under the low carbon economy. Energy 2010;35:4257–64.
[43] Lin BQ, Jiang ZJ, Lin J. The analysis and design of China's residential electricity tariff subsidies. Financial Research Journal 2009;11:48–58.
[44] Qi F, Zhang LZ, Wei B, Que GH. An application of ramsey pricing in solving the cross-subsidies in Chinese electricity tariffs. IEEE. Electric Utility Deregulation and Restructuring and Power Technologies 2008;4:442–7.
[45] Wu LX. The fluctuations of China's energy efficiency: theoretical explains, numerical simulations and policy experiments. Economic Research Journal 2009;5:130–42.